US009128425B2

(12) **United States Patent**
Suzuki et al.

(10) **Patent No.: US 9,128,425 B2**
(45) **Date of Patent: Sep. 8, 2015**

(54) **FIXING DEVICE HAVING END-FACE RESTRICTING MEMBERS APPLIED WITH LUBRICANT**

(71) Applicants: **Noboru Suzuki**, Komaki (JP); **Kei Ishida**, Nagoya (JP); **Takuji Matsuno**, Ichinomiya (JP)

(72) Inventors: **Noboru Suzuki**, Komaki (JP); **Kei Ishida**, Nagoya (JP); **Takuji Matsuno**, Ichinomiya (JP)

(73) Assignee: **Brother Kogyo Kabushiki Kaisha**, Nagoya-shi, Aichi-ken (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **13/736,239**

(22) Filed: **Jan. 8, 2013**

(65) **Prior Publication Data**

US 2013/0322937 A1 Dec. 5, 2013

(30) **Foreign Application Priority Data**

May 31, 2012 (JP) 2012-124780

(51) **Int. Cl.**
G03G 15/20 (2006.01)

(52) **U.S. Cl.**
CPC ***G03G 15/2003*** (2013.01); ***G03G 15/2053*** (2013.01); *G03G 15/2017* (2013.01); *G03G 2215/2035* (2013.01)

(58) **Field of Classification Search**
CPC G03G 2215/00151; G03G 15/2003; G03G 15/2017; G03G 15/2053; G03G 2215/2035
USPC 399/122, 329; 184/15.1
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,752,149	A *	5/1998	Yuza et al.	399/329
5,810,526	A *	9/1998	Hirai	409/131
6,961,532	B2 *	11/2005	Uekawa et al.	399/329
8,068,778	B2 *	11/2011	Kaino et al.	399/329
8,290,416	B2 *	10/2012	Kim	399/329
2007/0178296	A1 *	8/2007	Miekka	428/305.5
2011/0081174	A1 *	4/2011	Baba	399/329

FOREIGN PATENT DOCUMENTS

JP	04-081787	A	3/1992
JP	2004144833	A *	5/2004
JP	2008-275755	A	11/2008

OTHER PUBLICATIONS

Machine Translation of Kobayashi, Shinsuke. Heating Device, Nov. 13, 2008. Japanese Patent Office. JP2008-275755.*

* cited by examiner

Primary Examiner — Clayton E LaBalle
Assistant Examiner — Trevor J Bervik
(74) *Attorney, Agent, or Firm* — Banner & Witcoff, Ltd.

(57) **ABSTRACT**

A fixing device includes: a flexible tubular member defining an axis extending in an axial direction; a first fixing member; a second fixing member configured to nip the tubular member in cooperation with the first fixing member; and a pair of restricting members disposed to interpose the tubular member therebetween in the axial direction. The tubular member has end faces in the axial direction and a circumference defining a circumferential direction. Each restricting member has a restricting surface abuttable with each end face of the tubular member to restrict the tubular member from moving in the axial direction, each restricting surface having a specific area continuously applied with a lubricant upon completion of assembly of the fixing device, the specific area having an arcuate shape extending in the circumferential direction and having a width at least equal to a thickness of the tubular member in the radial direction.

15 Claims, 10 Drawing Sheets

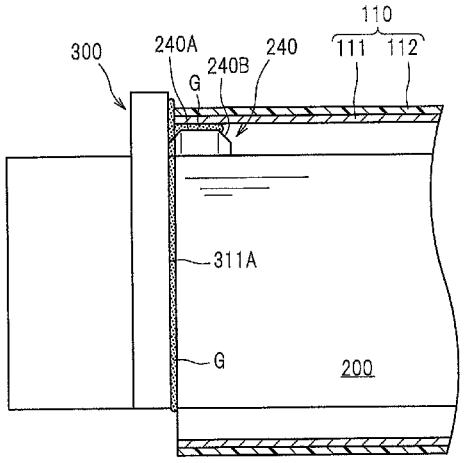


FIG. 1

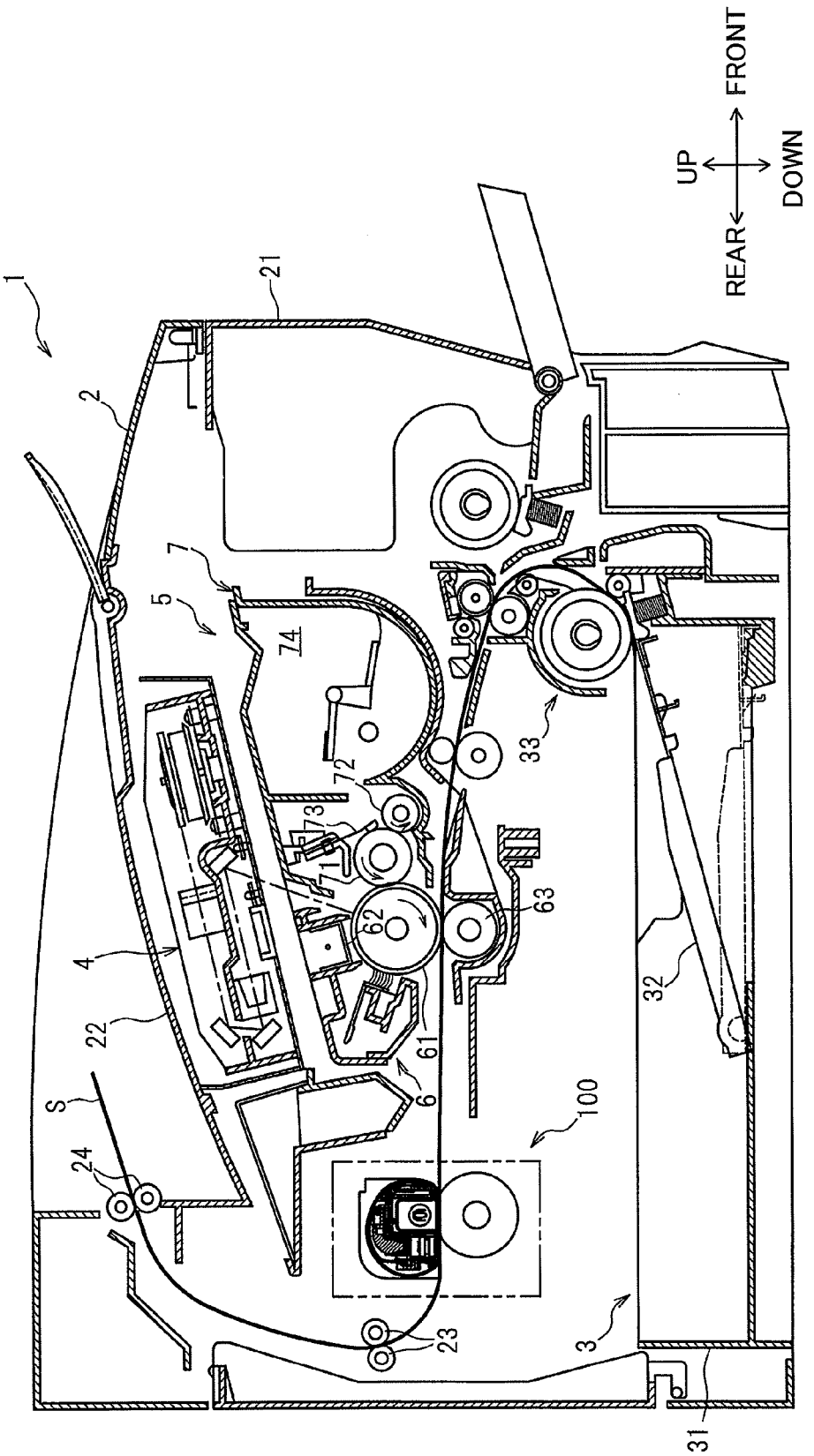

FRONT
UP
DOWN
REAR
1
2
21
7
5
74
72
73
71
62
61
63
33
4
22
32
S
6
100
24
23
3
31

FIG. 2

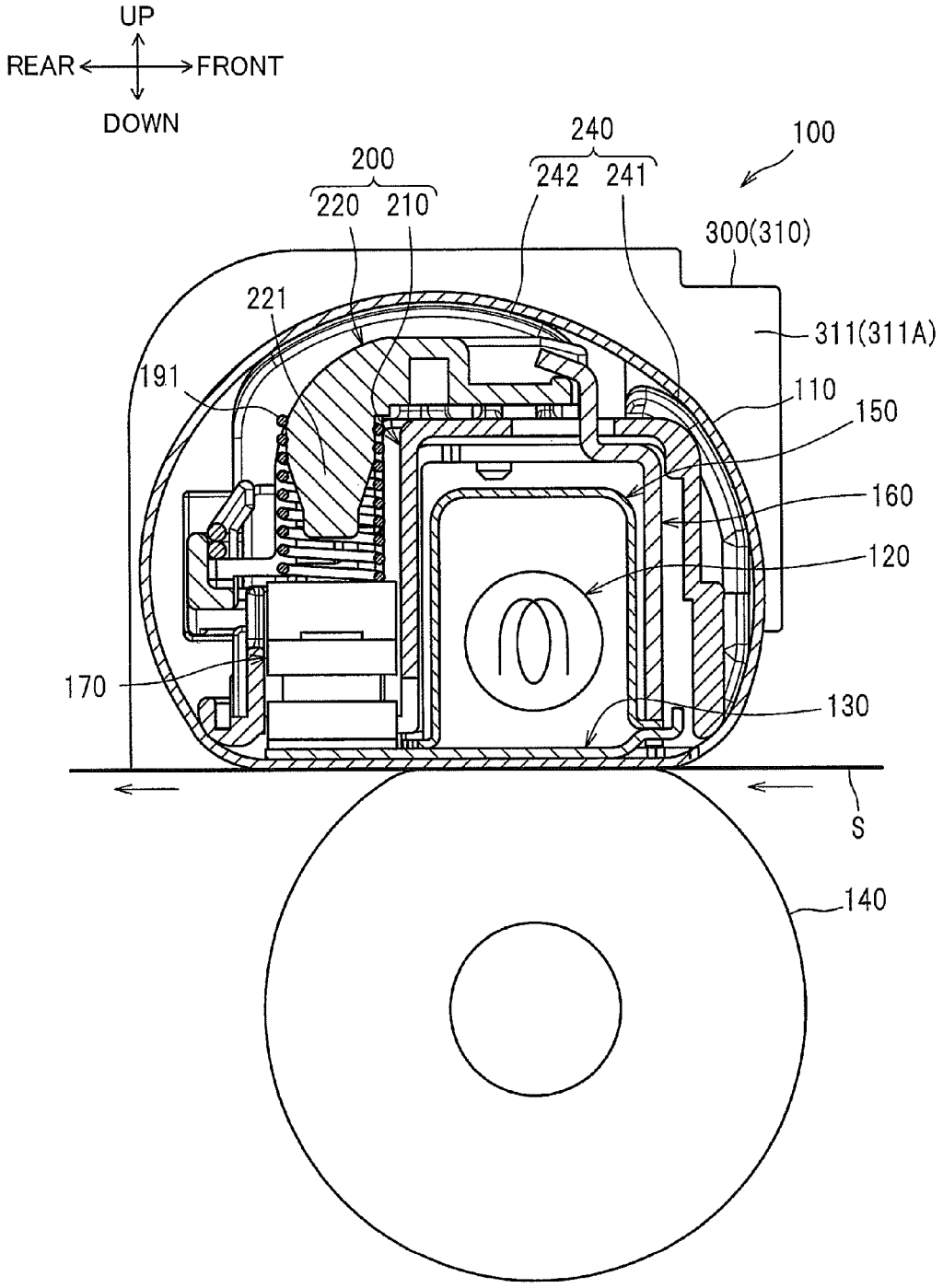

UP
REAR
FRONT
DOWN
200
220
210
240
242
241
100
300(310)
221
311(311A)
191
110
150
160
120
170
130
S
140

FIG. 3

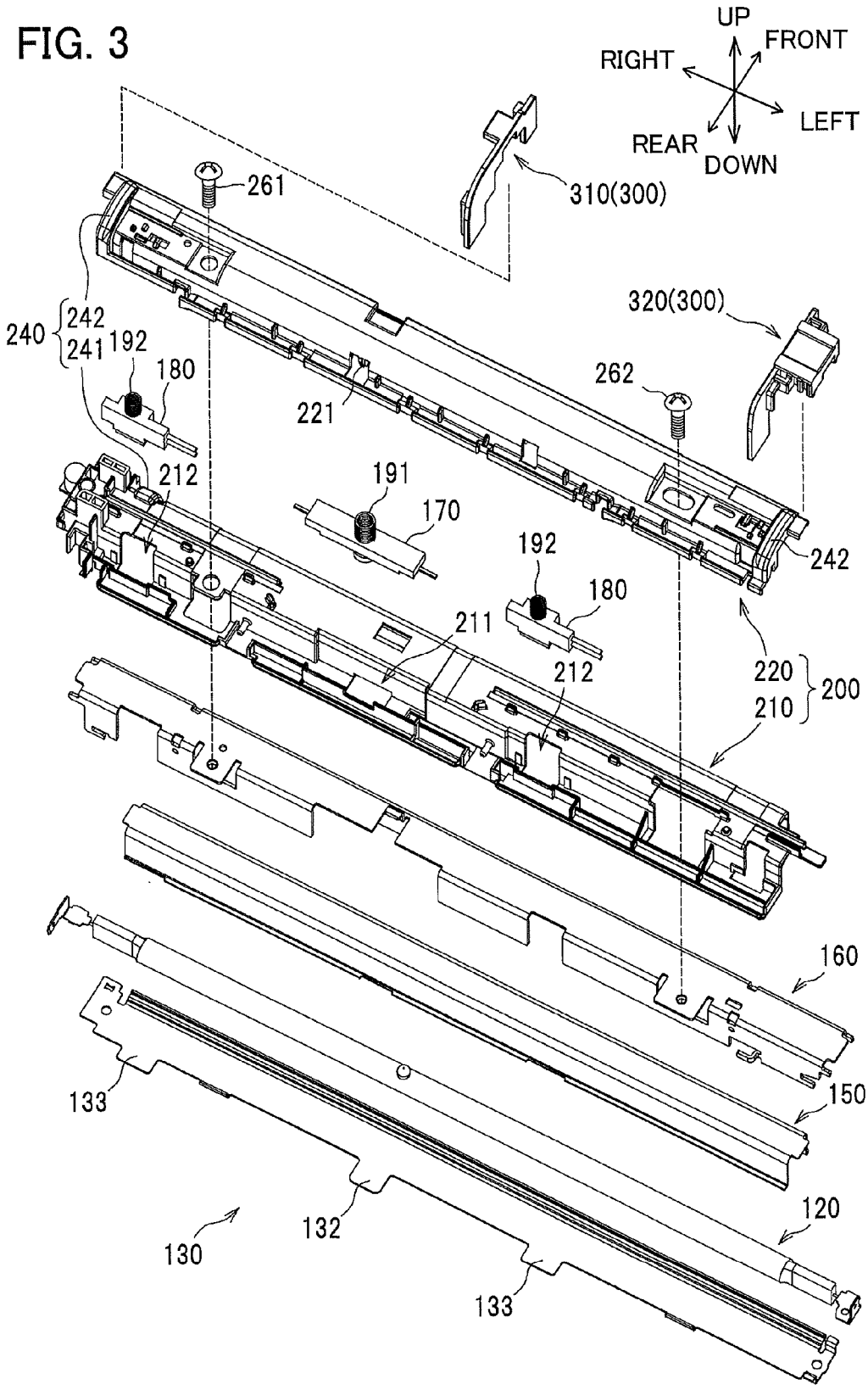

UP
FRONT
RIGHT
LEFT
REAR
DOWN
261
310(300)
320(300)
240
242
241
192
180
262
221
212
191
170
192
180
242
211
212
220
210
200
160
133
150
120
132
130
133

FIG. 4A

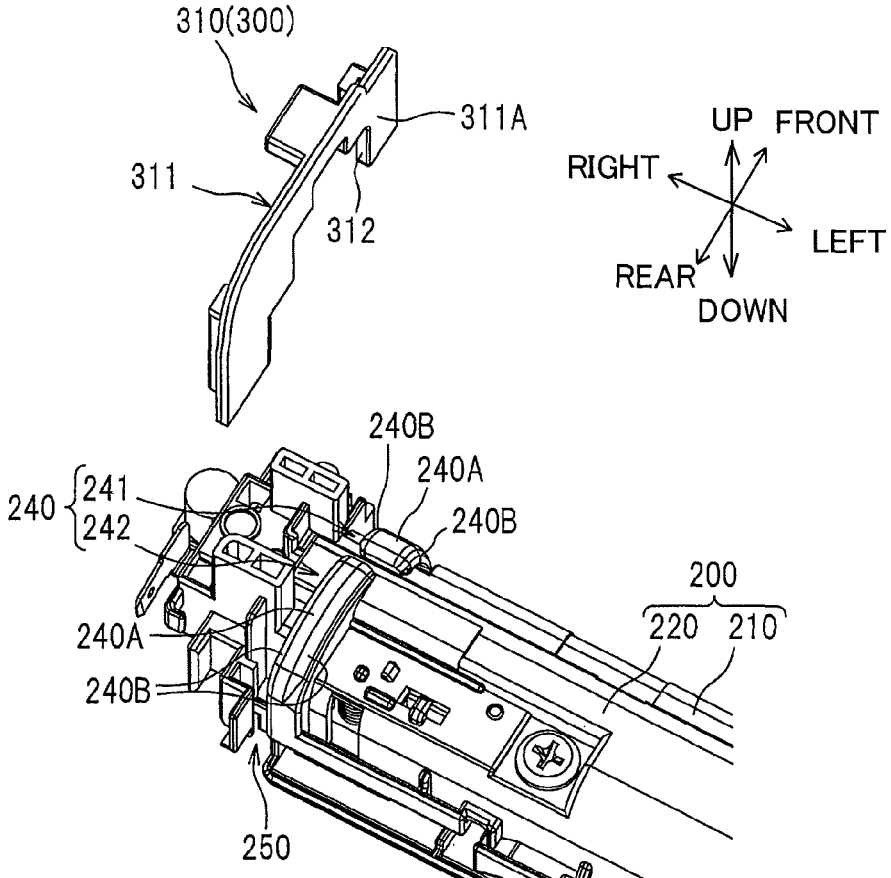

310(300)
311A
311
312
UP
FRONT
RIGHT
LEFT
REAR
DOWN
240B
240A
240
241
242
240B
200
220
210
240A
240B
250

FIG. 4B

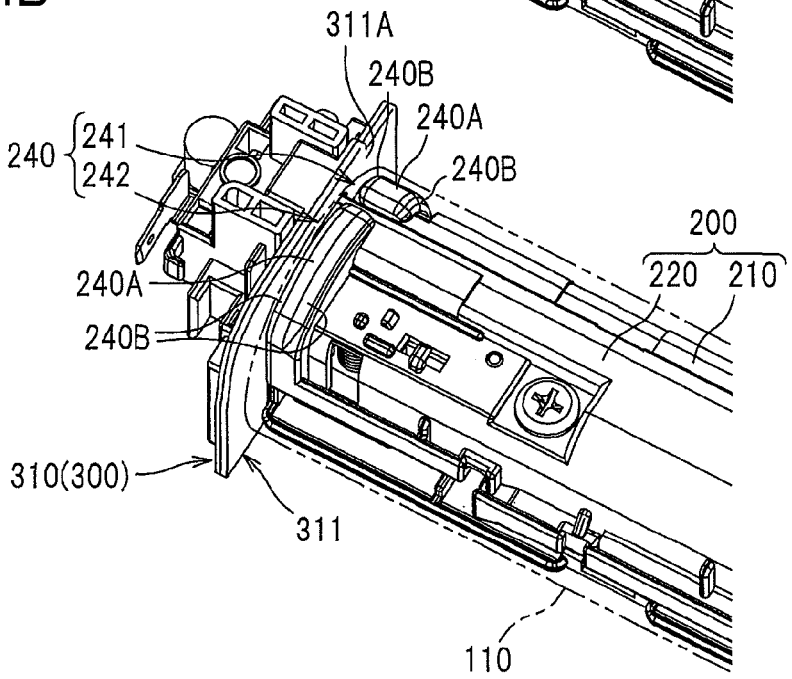

311A
240B
240A
240
241
242
240B
200
220
210
240A
240B
310(300)
311
110

FIG. 5A

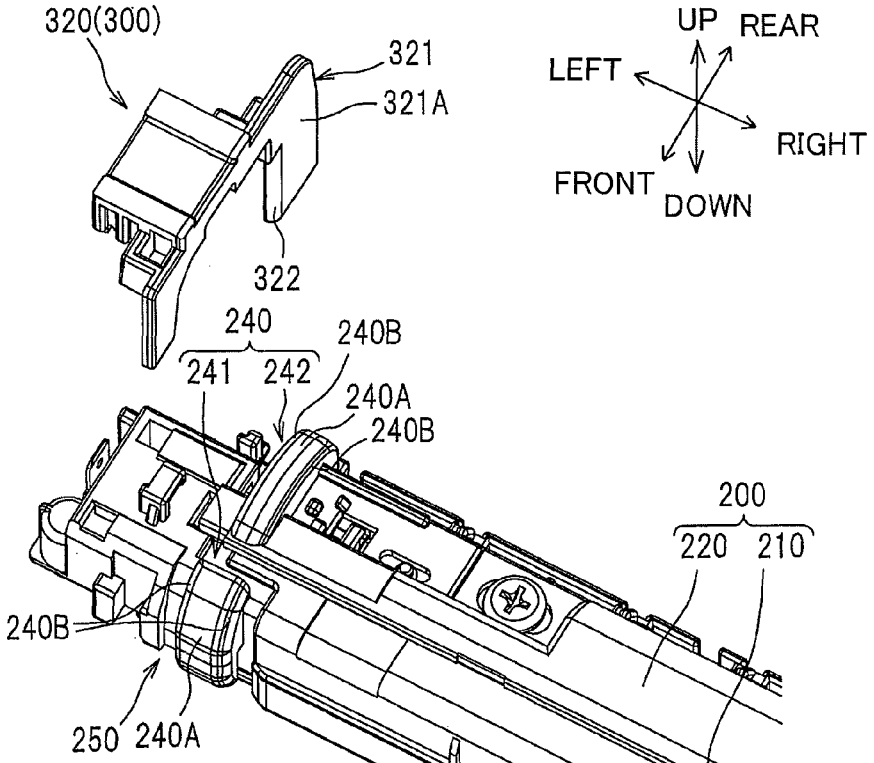

320(300)
321
321A
322
UP
REAR
LEFT
RIGHT
FRONT
DOWN
240
241
242
240B
240A
240B
200
220
210
240B
250
240A

FIG. 5B

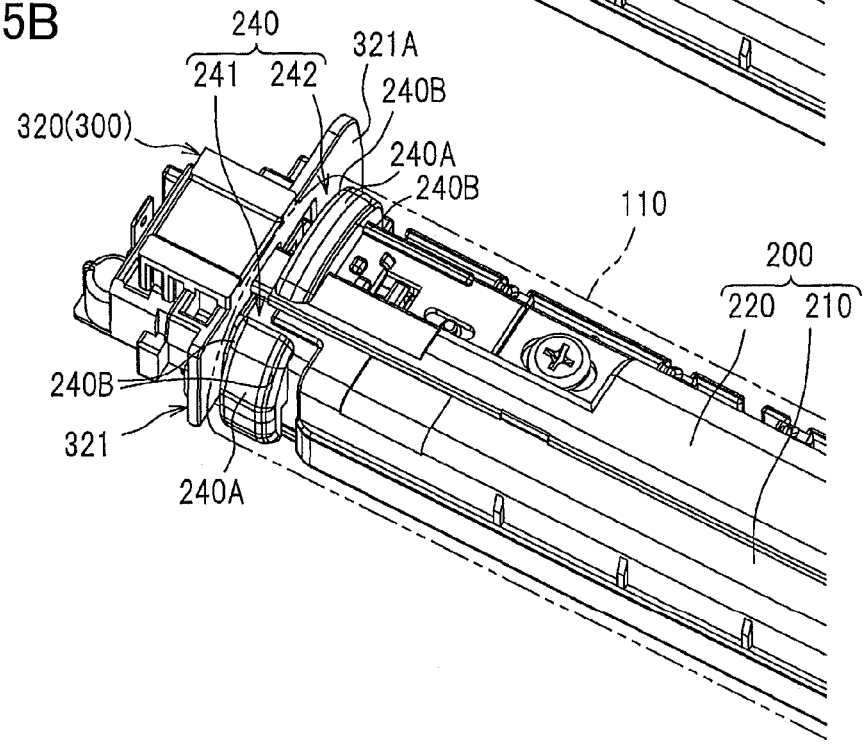
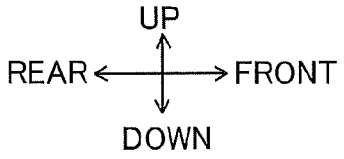

240
241
242
321A
240B
320(300)
240A
240B
110
200
220
210
240B
321
240A

FIG. 6A


UP
REAR
FRONT
DOWN

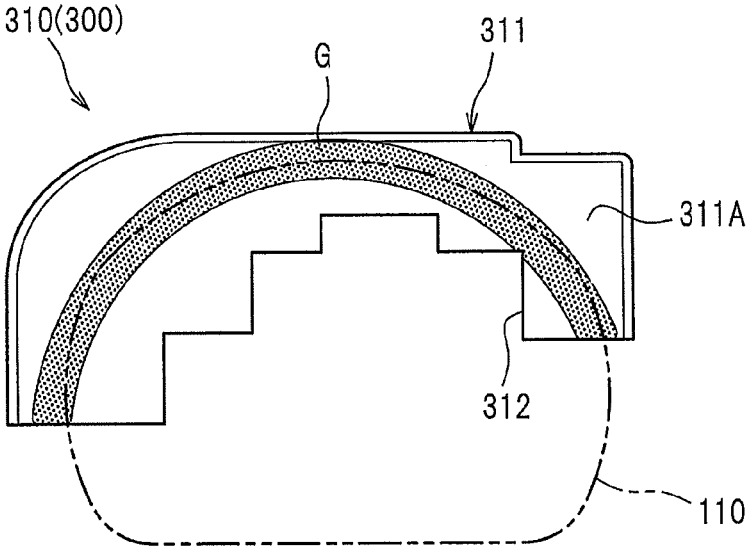
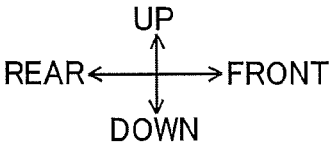

310(300)
G
311
311A
312
110

FIG. 6B


UP
REAR
FRONT
DOWN

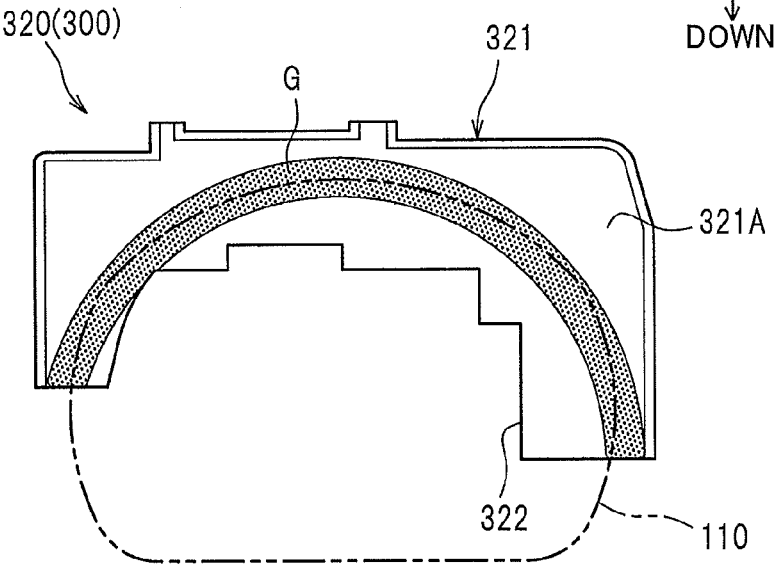

320(300)
G
321
321A
322
110

FIG. 7

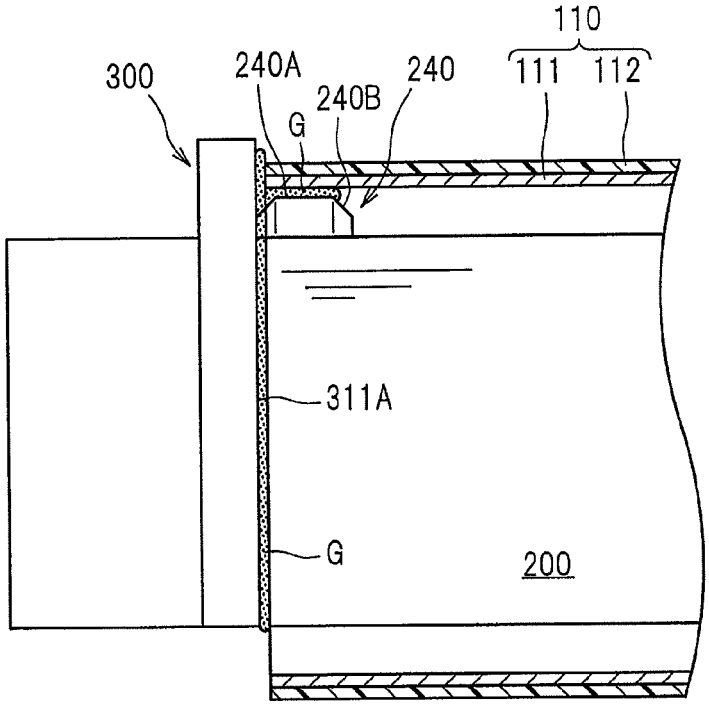

110
300
240A
240
240B
G
111
112
311A
G
200

FIG. 8

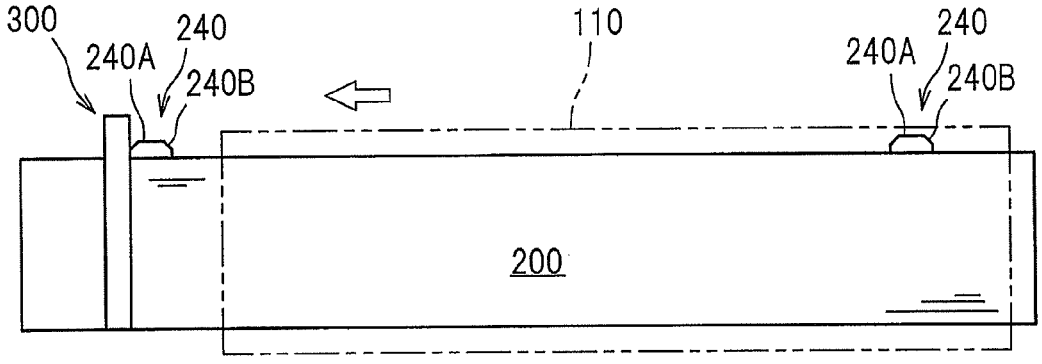

300
240A
240
240B
110
240A
240
240B
200

FIG. 9A

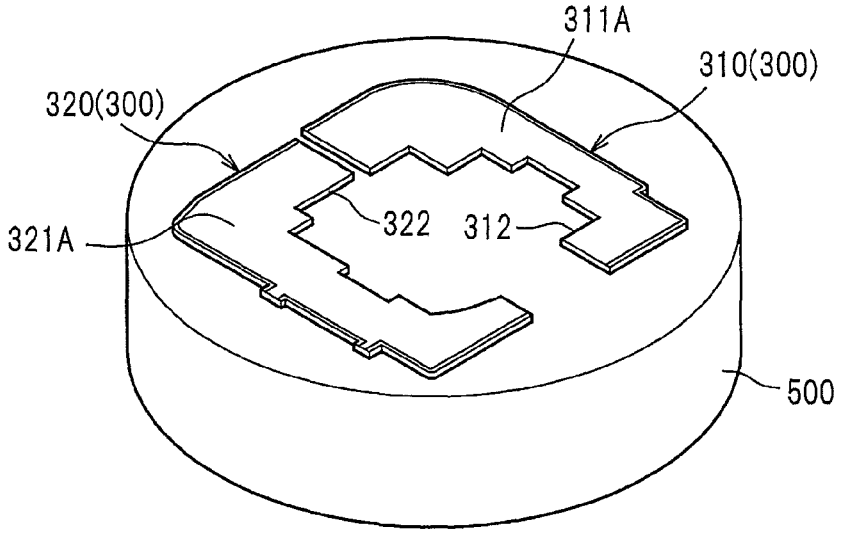


FIG. 9B

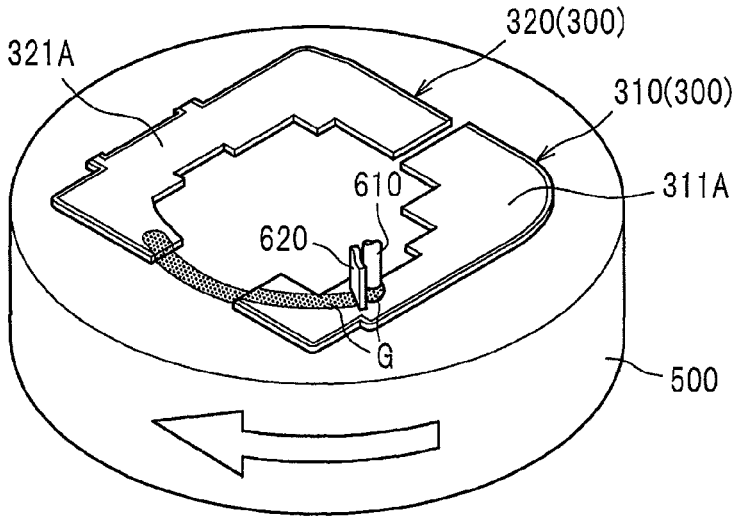


FIG. 9C

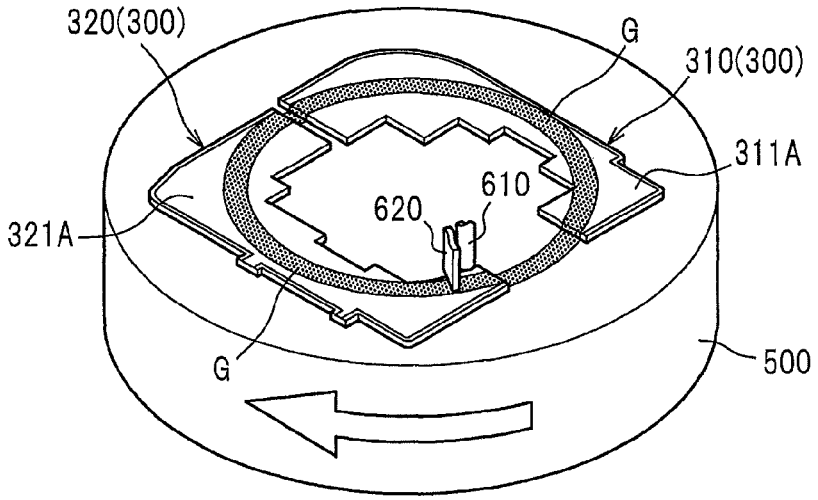


FIG. 10

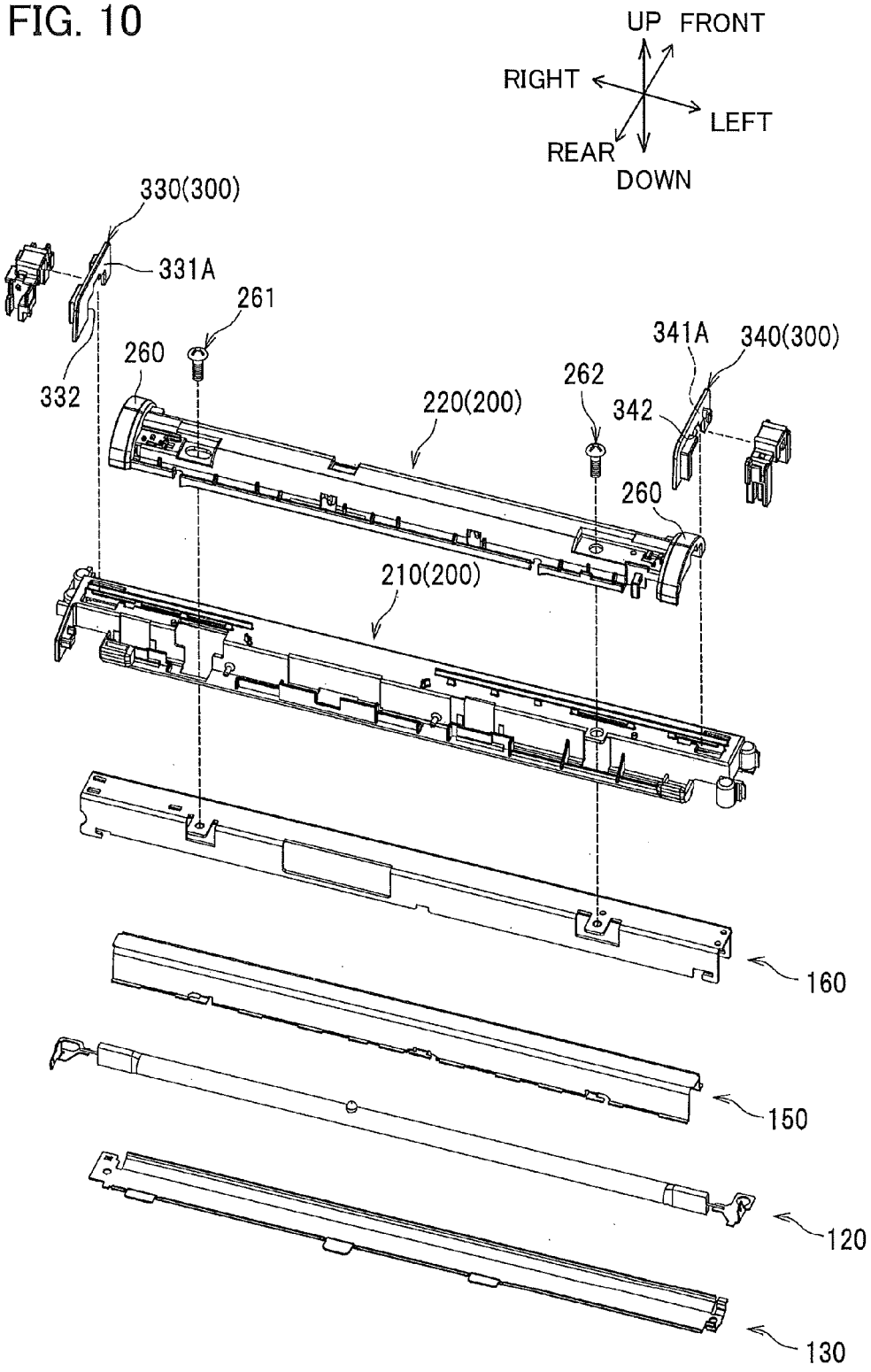
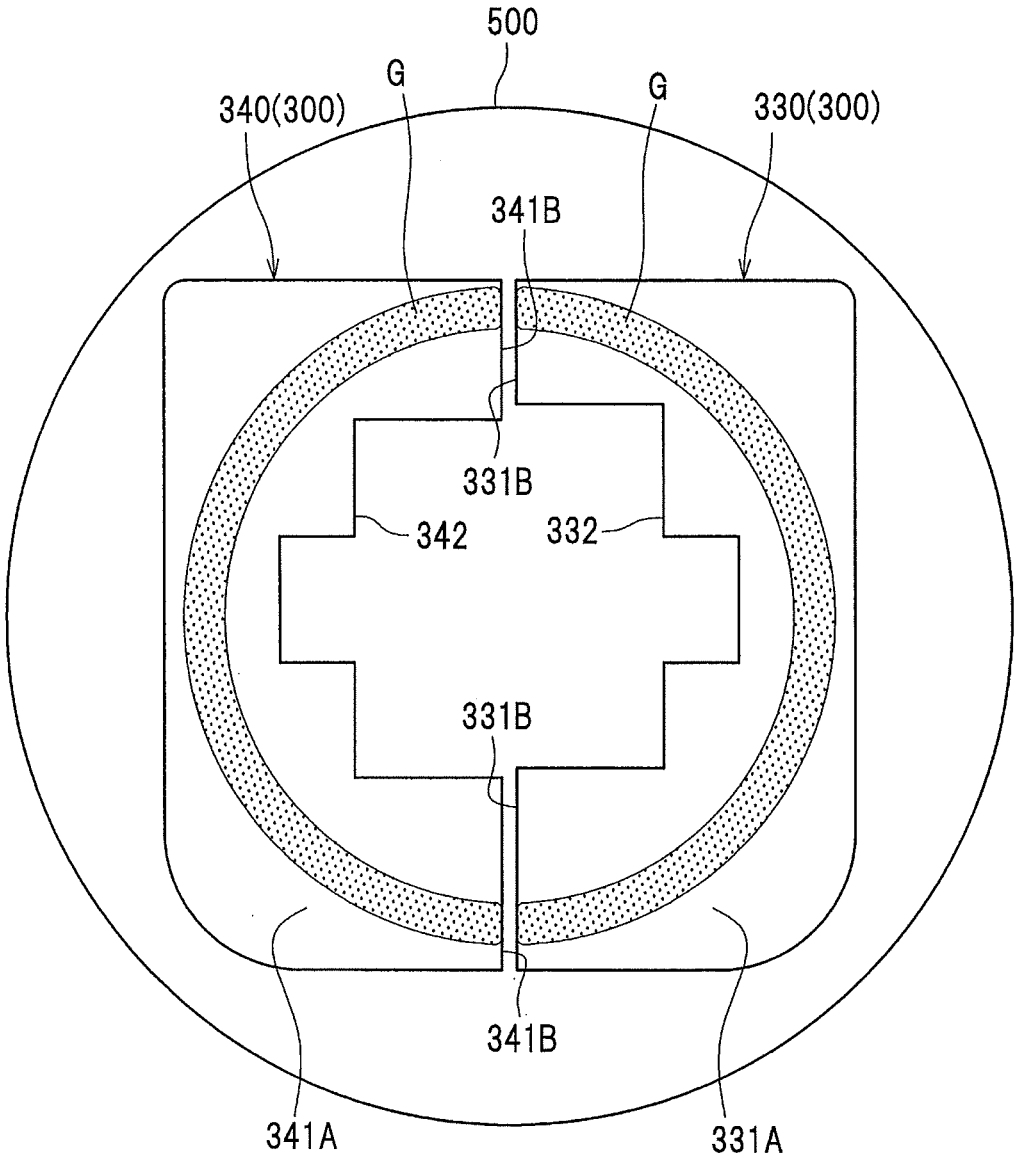

UP
FRONT
RIGHT
LEFT
REAR
DOWN
330(300)
331A
261
260
332
220(200)
262
341A
340(300)
342
260
210(200)
160
150
120
130

FIG. 11



FIXING DEVICE HAVING END-FACE RESTRICTING MEMBERS APPLIED WITH LUBRICANT

CROSS REFERENCE TO RELATED APPLICATION

This application claims priority from Japanese Patent Application No. 2012-124780 filed May 31, 2012. The entire content of the priority application is incorporated herein by reference.

TECHNICAL FIELD

The present invention relates to a fixing device for thermally fixing a developing agent image onto a sheet.

BACKGROUND

There has been proposed a fixing device that includes a tubular fusing film whose inner peripheral surface is guided by a guide member, a pressure roller configured to nip the fusing film in cooperation with the guide member, and a flange configured to restrict end faces of the fusing film. The flange serves to restrict the fusing film from moving in a longitudinal direction thereof.

SUMMARY

In such a fixing device, a lubricant such as grease is often applied between an end face of a fusing film (tubular member) and a flange (end-face restricting member). However, when the lubricant is applied in a dot-like pattern, the end face of the tubular member and the end-face restricting member may directly abut against each other. Under such circumstances, it is likely that the end-face restricting member may end with up a rough surface (with irregularity) due to attrition caused by the direct sliding contact between the end-face restricting member and the end face of the circularly-moving tubular member. As a result, the end face of the tubular member may be damaged due to its direct contact with the rough surface of the end-face restricting member. A crack or split would possibly result on the damaged end face of the tubular member.

Thus, it is an object of the present invention to provide a thermal fixing device capable of providing prolonged service life of the tubular member.

In order to attain the above and other objects, there is provided a fixing device for thermally fixing a developing agent image to a sheet, the fixing device including: a flexible tubular member; a first fixing member; a second fixing member; and a pair of restricting members. The flexible tubular member has an inner peripheral surface defining an internal space, the flexible tubular member being circularly movable while the developing agent image is thermally fixed, the flexible tubular member defining an axis extending in an axial direction and having end faces in the axial direction, the flexible tubular member having a circumference defining a circumferential direction and having a thickness in a radial direction perpendicular to the axial direction. The first fixing member is disposed at the internal space, and the second fixing member is configured to nip the flexible tubular member in cooperation with the first fixing member. The restricting members are disposed to interpose the flexible tubular member therebetween in the axial direction, each restricting member having a restricting surface abuttable with each end face of the flexible tubular member to restrict the flexible tubular member from moving in the axial direction, each restricting surface having a specific area applied with a lubricant in a continuous manner when assembly of the fixing device has been completed, the specific area having an arcuate shape extending in the circumferential direction and having a width at least equal to the thickness of the flexible tubular member in the radial direction.

According to another aspect of the present invention, there is provided a method for producing a fixing device for thermally fixing a developing agent image to a sheet. The fixing device includes: a flexible tubular member having an inner peripheral surface defining an internal space, the flexible tubular member being circularly movable while the developing agent image is thermally fixed, the flexible tubular member defining an axis extending in an axial direction and having end faces in the axial direction, the flexible tubular member having a circumference defining a circumferential direction; a first fixing member disposed at the internal space; a second fixing member configured to nip the flexible tubular member in cooperation with the first fixing member; and a pair of restricting members disposed to interpose the flexible tubular member therebetween in the axial direction, each restricting member having a restricting surface abuttable with each end face of the flexible tubular member to restrict the flexible tubular member from moving in the axial direction. The method includes: applying a lubricant onto the restricting surfaces in a continuous manner such that the lubricant extends along the circumferential direction of the flexible tubular member; and positioning each restricting surface to confront each end face of the flexible tubular member in the axial direction, the positioning being executed after the applying.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings;

FIG. **1** is a schematic cross-sectional view of a laser printer having a fixing device according to an embodiment of the present invention;

FIG. **2** is an enlarged schematic cross-sectional view showing a structure of the fixing device according to the embodiment;

FIG. **3** is an exploded perspective view of the fixing device according to the embodiment, the fixing device including a right end-face restricting member, a left end-face restricting member **320**, and a frame assembly;

FIG. **4**A is a view showing a state where the right end-face restricting member is removed from the frame assembly;

FIG. **4**B is a view showing a state where the right end-face restricting member has been assembled to the frame assembly;

FIG. **5**A is a view showing a state where the left end-face restricting member is removed from the frame assembly;

FIG. **5**B is a view showing a state where the left end-face restricting member has been assembled to the frame assembly;

FIG. **6**A is a plan view of a restricting surface of the right end-face restricting member;

FIG. **6**B is a plan view of a restricting surface of the left end-face restricting member;

FIG. **7** is an explanatory view illustrating technical advantages of inner guides formed adjacent to the end-face restricting members;

FIG. **8** is an explanatory view illustrating technical advantages of the inner guides formed with sloped surfaces;

FIGS. **9**A to **9**C illustrate steps of a lubricant application process performed during production of the fixing device of the embodiment;

FIG. **10** is an exploded perspective view of a fixing device according to a first modification of the present invention; and

FIG. **11** is a plan view showing a state where right and left end-face restricting members according to a second modification of the present invention are placed in a jig and applied with a lubricant.

DETAILED DESCRIPTION

First, a general construction of a laser printer **1** that is provided with a fixing device **100** according to an embodiment of the present invention will be described with reference to FIG. **1**. Then, a detailed configuration of the fixing device **100** will be described with reference to FIGS. **2**-**9**C.

Throughout the specification, the terms "above", "below", "right", "left", "front", "rear" and the like will be used assuming that the laser printer **1** is disposed in an orientation in which it is intended to be used. More specifically, in FIG. **1**, a right side, a left side, a near side and a far side of the laser printer **1** are referred to as a front side, a rear side, a left side and a right side, respectively.

<General Construction of the Laser Printer>

As shown in FIG. **1**, the laser printer **1** includes a main frame **2** provided with a movable front cover **21**. Within the main frame **2**, a sheet supply unit **3** for supplying a sheet S, an exposure unit **4**, a process cartridge **5** for transferring a toner image (developing agent image) on the sheet S, and the fixing device **100** for thermally fixing the toner image onto the sheet S are provided.

The sheet supply unit **3** is disposed at a lower portion of the main frame **2**. The sheet supply unit **3** includes a sheet supply tray **31** for accommodating the sheet S, a lifter plate **32** for lifting up a front side of the sheet S and a sheet supplying mechanism **33**. Each sheet S accommodated in the sheet supply tray **31** is directed upward by the lifter plate **32** and supplied toward the process cartridge **5** (between a photosensitive drum **61** and a transfer roller **63**) by the sheet supplying mechanism **33**. A path along which the sheet S is conveyed within the main frame **2** (sheet conveying path) is shown by a thick solid line in FIG. **1**.

The exposure unit **4** is disposed at an upper portion of the main frame **2**. The exposure unit **4** includes a laser emission unit (not shown), a polygon mirror, lenses and reflection mirrors (shown without reference numerals). In the exposure unit **4**, the laser emission unit emits a laser beam (indicated by a chain line in FIG. **1**) based on image data. A surface of the photosensitive drum **61** is exposed to light by the laser beam at a high speed.

The process cartridge **5** is disposed below the exposure unit **4**. The process cartridge **5** is detachably loadable in the main frame **2** through an opening defined when the front cover **21** of the main frame **2** is opened.

The process cartridge **5** includes a drum unit **6** and a developing unit **7**.

The drum unit **6** includes the photosensitive drum **61**, a charger **62**, and the transfer roller **63**. The developing unit **7** is detachably mountable on the drum unit **6** and includes a developing roller **71**, a supply roller **72**, a thickness-regulation blade **73**, and a toner accommodating portion **74** in which toner (developer) is accommodated.

In the process cartridge **5**, after the surface of the photosensitive drum **61** is uniformly charged by the charger **62**, the surface is exposed to the high speed scan of the laser beam from the exposure unit **4**. An electrostatic latent image based on the image data is thereby formed on the surface of the photosensitive drum **61**. The toner accommodated in the toner accommodating portion **74** is supplied to the developing roller **71** via the supply roller **72**. The toner then enters between the developing roller **71** and the thickness-regulation blade **73** and is carried on the developing roller **71** as a thin layer having a uniform thickness.

The toner borne on the developing roller **71** is supplied to the electrostatic latent image formed on the photosensitive drum **61**, thereby forming a visible toner image on the surface of the photosensitive drum **61**. Then, the sheet S is conveyed between the photosensitive drum **61** and the transfer roller **63**, so that the toner image formed on the photosensitive drum **61** is transferred onto the sheet S.

The fixing device **100** is disposed rearward of the process cartridge **5**. The toner image (toner) transferred onto the sheet S is thermally fixed on the sheet S while the sheet S passes through the fixing device **100**. The sheet S on which the toner image is thermally fixed is then conveyed by conveying rollers **23** and **24**, and discharged onto a discharge tray **22** formed on an upper surface of the main frame **2**.

<Detailed Structure of the Fixing Device>

Next, a detailed structure of the fixing device **100** will be described with reference to FIGS. **2** to **7**.

As shown in FIGS. **2** and **3**, the fixing device **100** includes a flexible fusing belt **110** as a tubular member, a halogen lamp **120** as a heater, a nip plate **130** as a first fixing member, a backup roller **140** as a second fixing member, a reflection member **150**, a stay **160**, a thermostat **170**, two thermistors **180**, a frame assembly **200**, a pair of end-face restricting members **300** (a right end-face restricting member **310** and a left end-face restricting member **320**).

The fusing belt **110** is of an endless belt (of a tubular configuration) having heat resistivity and flexibility. The fusing belt **110** has an inner peripheral surface that defines an internal space within which the halogen lamp **120**, the nip plate **130**, the reflection member **150**, the stay **160** and the frame assembly **200** are disposed. The fusing belt **110** extends in a left-to-right direction. Hereinafter, the left-to-right direction in which the fusing belt **110** extends may also be referred to as an axial direction of the fusing belt **110**, wherever necessary. The fusing belt **110** has widthwise end portions in the axial direction that are guided by inner guides **240** (described later) so that the fusing belt **110** is circularly movable therealong.

In the embodiment, as shown in FIG. **7**, the fusing belt **110** is configured of a base tube **111**, and a coating layer **112** formed on an outer peripheral surface of the base tube **111**. The base tube **111** is made of a metal such as stainless steel, and the coating layer **112** is made of a fluorine resin. The coating layer **112** covers the entire outer peripheral surface of the base tube **111**, but both widthwise end faces of the base tube **111** (only one is shown in FIG. **7**) are exposed outside in the axial direction. The fusing belt **110** therefore has a predetermined thickness in a radial direction thereof.

The halogen lamp **120** is a heater to generate radiant heat to heat the nip plate **130** and the fusing belt **110** for heating toner on the sheet S. The halogen lamp **120** is positioned at the internal space of the fusing belt **110** such that the halogen lamp **120** is spaced away from an inner surface of the nip plate **130** by a predetermined distance, as shown in FIG. **2**.

The nip plate **130** has a plate-like shape and is adapted to receive radiant heat from the halogen lamp **120**. To this effect, the nip plate **130** is positioned at the internal space of the fusing belt **110** such that the inner peripheral surface of the fusing belt **110** is slidably movable with a lower surface of the nip plate **130**. The nip plate **130** is made from a metal. In the embodiment, the nip plate **130** is made of aluminum having a relatively high thermal conductivity. The nip plate **130** has a

rear edge portion from which three protruding portions **132**, **133** protrude rearward, as shown in FIG. **3**.

The backup roller **140** is disposed below the nip plate **130** such that the backup roller **140** nips the fusing belt **110** in cooperation with the nip plate **130**, as shown in FIG. **2**, to convey the sheet S.

The backup roller **140** is configured to rotate upon receipt of a driving force transmitted from a motor (not shown) disposed within the main frame **2**. As the backup roller **140** rotates, the fusing belt **110** is circularly moved along the nip plate **130** because of a friction force generated between the back-up roller **140** and the fusing belt **110** or between the sheet S and the fusing belt **110**. The toner image on the sheet S can be thermally fixed thereto by heat and pressure during passage of the sheet S between the backup roller **140** and the fusing belt **110**.

The reflection member **150** is adapted to reflect radiant heat from the halogen lamp **120** toward the nip plate **130**. As shown in FIG. **2**, the reflection member **150** is positioned at the internal space of fusing belt **110** to surround the halogen lamp **120** with a predetermined distance therefrom. Thus, heat from the halogen lamp **120** can be efficiently concentrated onto the nip plate **130** to promptly heat the nip plate **130** and the fusing belt **110**.

The reflection member **150** has a U-shaped cross-section and is made from a material such as aluminum having high reflection ratio regarding infrared ray and far infrared ray.

The stay **160** is adapted to support the nip plate **130** via the reflection member **150**. The stay **160** is thus adapted to receive pressure (load) applied from the backup roller **140** to maintain rigidity of the nip plate **130**. The stay **160** is disposed at the internal space of the fusing belt **110** so as to cover the halogen lamp **120** and the reflection member **150**. For fabricating the stay **160**, a highly rigid member such as a steel plate is folded into U-shape.

The thermostat **170** and the thermistors **180** are configured to detect a temperature of the nip plate **130**. Each of the thermostat **170** and the thermistors **180** has a lower surface serving as a temperature detecting surface. As shown in FIG. **2**, the thermostat **170** and the thermistors **180** are disposed at the internal space of the fusing belt **110** such that lower surfaces of the thermostat **170** and the thermistors **180** oppose upper surfaces of the protruding portions **132**, **133** of the nip plate **130** respectively. The thermostat **170** and the thermistors **180** are respectively biased toward the protruding portions **132**, **133** by coil springs **191**, **192**. With this construction, the thermostat **170** and the thermistors **180** are stably positioned relative to the nip plate **130**. Hence, the thermostat **170** and the thermistors **180** can detect the temperature of the nip plate **130** with accuracy.

The thermostat **170** is connected to the halogen lamp **120** and is configured to shut off power supply to the halogen lamp **120** upon detection of a predetermined temperature. The thermistors **180** are configured to output detected temperatures to a control circuit (not shown) provided in the main frame **2** for controlling the halogen lamp **120** (temperature of the fixing device **100**).

The frame assembly **200** is adapted to support the thermostat **170**, the thermistors **180** and the end-face restricting members **300**. The frame assembly **200** is disposed at the internal space of the fusing belt **110** so as to cover the stay **160**, as shown in FIG. **2**.

The frame assembly **200** includes a first frame member **210** and a second frame member **220**, as shown in FIG. **3**.

The first frame member **210** extends in the left-to-right direction and has a substantially U-shaped cross-section so as to cover the stay **160**. The first frame member **210** is formed with a first positioning portion **211** and two second positioning portions **212**. The first positioning portion **211** is adapted to be coupled with the thermostat **170**, while the second positioning portions **212** are adapted to be coupled with the thermistors **180**. The thermostat **170** and the thermistors **180** are thus positioned in the front-to-rear direction as well as in the left-to-right direction.

As shown in FIGS. **2** and **3**, the second frame member **220** has a substantially L-shaped cross-section and extends in the left-to-right direction to cover the first frame member **210**. The second frame member **220** has an upper wall on which three supporting portions **221** (only one is shown in FIG. **3**) are formed. Specifically, each supporting portion **221** has a boss-like shape protruding downward from a lower surface of the upper wall of the second frame member **220** for supporting one of the coil springs **191**, **192**. The coil springs **191**, **192** are engaged with respective supporting portions **221** such that the coil springs **191**, **192** are interposed between the upper wall of the second frame member **220** and the thermistor **170** or the thermistors **180** in a compressed state.

The first frame member **210** and the second frame member **220** are fixed to the stay **160** by screws **261**, **262** in a state where cables connecting between the halogen lamp **120** and the thermistor **170** (not shown) are interposed between the first frame member **210** and the second frame member **220**.

As shown in FIGS. **4**A through **5**B, the frame assembly **200** has left and right end portions on each of whose outer surface the inner guide **240** and a mounting portion **250** are formed.

The inner guides **240** are adapted to be in sliding contact with the inner peripheral surface of the fusing belt **110** to guide the circular movement of the fusing belt **110** (also see FIG. **2**). Each inner guide **240** is configured of a first guide **241** formed on the first frame member **210** and a second guide **242** formed on the second frame member **220** (also see FIG. **3**).

Each first guide **241** is formed on each widthwise end portion of the first frame member **210** to protrude generally frontward therefrom (toward the inner peripheral surface of the fusing belt **110**) and has an arcuate shape in a side view.

Each second guide **242** is formed on each widthwise end portion of the second frame member **220** to protrude generally upward therefrom (toward the inner peripheral surface of the fusing belt **110**) and has an arcuate shape in a side view.

Each inner guide **240** (the first guide **241** and second guide **242** as assembled) is formed with a guide surface **240**A and two sloped surfaces **240**B (also see FIG. **7**, **8**). The guide surface **240**A extends in a direction substantially parallel to the inner peripheral surface of the fusing belt **110** so as to guide the same. Each sloped surface **240**B extends from the guide surface **240**A either leftward or rightward and slopes toward the upper wall of the second frame member **220** (or in a direction away from the inner peripheral surface of the fusing belt **110** and the guide surface **240**A).

Each mounting portion **250** is adapted to be engaged with each end-face restricting member **300** (the right end-face restricting member **310** or the left end-face restricting member **320**). Each mounting portion **250** is arranged outward (rightward or leftward) of the corresponding inner guide **240** in the left-to-right direction. In other words, in the present embodiment, each inner guide **240** is provided laterally inward of and adjacent to each end-face restricting member **300** mounted on the frame assembly **200** in the left-right direction.

The pair of end-face restricting members **300** serves to restrict position of the fusing belt **110** in the axial direction. The end-face restricting members **300** include the right end-face restricting member **310** for restricting a right end face of

the fusing belt **110**, and the left end-face restricting member **320** for restricting a left end face of the fusing belt **110**.

The right end-face restricting member **310** includes a plate-like shaped restricting portion **311** and an engaged portion **312**, as shown in FIG. **4**A, whereas the left end-face restricting member **320** includes a plate-like shaped restricting portion **321** and an engaged portion **322**, as shown in FIG. **5**A. The engaged portions **312** and **322** are formed so as to be recessed upward from lower ends of the restricting portions **311** and **321**, respectively.

The restricting portion **311** has a left surface **311**A that is abuttable with the right end face of the fusing belt **110** as the fixing device **100** circularly moves. The restricting plate **321** has a right surface **321**A that is abuttable with the left end face of the fusing belt **110** as the fixing device **100** circularly moves. Thus, the left surface **311**A of the restricting portion **311** and the right surface **321**A of the restricting portion **321** respectively serve as restricting surfaces **311**A, **321**A for restricting the fusing belt **110** (the right and left end faces of the fusing belt **110**) from moving in the axial direction. The restricting surfaces **311**A and **321**A are formed as a flat surface without irregularities. It should be noted that, in the embodiment, "a flat surface without irregularities" means neither the restricting surface **311**A nor the restricting surface **321**A is integrally formed with any protruding portions, for example, for guiding the inner peripheral surface or outer peripheral surface of the fusing belt **110**.

As illustrated in FIGS. **6**A and **6**B, a lubricant G is applied onto the restricting surfaces **311**A and **321**A. More specifically, the lubricant G is continuously applied in a specific area on each of the restricting surfaces **311**A and **321**A, the specific area having an arcuate shape extending along a circumferential direction of the fusing belt **110**. That is, the right and left end-face restricting members **310**, **320** are formed with the specific area which is completely and evenly covered with the lubricant G in its entirety. For the purpose of preventing direct contact between each end face of the fusing belt **110** and each restricting surfaces **311**A, **321**A, this specific area should have a width in the radial direction at least equal to the thickness of the fusing belt **110**.

Preferably, considering that the fusing belt **110** may slightly move (fluctuate) in the radial direction while the fusing belt **110** is circularly moving, the lubricant G may be continuously applied such that the width of the arcuate-shaped specific area in the radial direction spans a range within which each end face of the fusing belt **110** is possibly abuttable with corresponding restricting surface **311**A or **321**A during the circular movement of the fusing belt **110**. More specifically, assuming that the end faces of the fusing belt **110** are possibly displaced from its innermost position and its outermost position in the radial direction during its circular movement, the width of the specific area may be set to span at least between the innermost position and the outermost position of each end face of the fusing belt **110**. The width of the lubricant G in the radial direction can be appropriately set in accordance with how much the fusing belt **110** moves (displaces or fluctuates) in the radial direction. For example, the width of the lubricant G may be set to 4.0-4.5 mm. As the lubricant G, a thermally-resistant fluorine grease is available, for example.

In the present embodiment, when the fixing device **100** is in a brand-new state or the fixing device **100** has just been assembled, the lubricant G has already been continuously applied in the arcuate-shaped specific area extending along the circumferential direction of the fusing belt **110** on each of the restricting surfaces **311**A, **321**A. In other words, the lubricant G has already been applied on the restricting surfaces **311**A, **321**A along the circumferential direction of the fusing belt **110**, before the fusing belt **110** is initially circularly moved: that is, the lubricant G is not spread by the end faces of the fusing belt **110** after the fixing device **100** is disposed in the laser printer **1**.

As illustrated in FIGS. **4**A through **5**B, the engaged portions **312** and **322** are adapted to be engaged with the mounting portions **250** formed in the frame assembly **200**. The end-face restricting members **300** are fixed to the frame assembly **200** mainly through the engagement of the engaged portions **312** and **322** with the corresponding mounting portions **250**.

With the above-described configuration, following operations and technical advantages can be achieved.

As illustrated in FIG. **6**, in the brand-new fixing device **100**, the lubricant G has already been continuously applied between each end face of the fusing belt **110** and each of the restricting surfaces **311**A and **321**A in the circumferential direction of the fusing belt **110**. Hence, direct abutment between the end faces of the fusing belt **110** and the restricting surfaces **311**A and **321**A can be prevented from the beginning of the use of the fixing device **100**. Further, the lubricant G is applied in an arcuate shape having a predetermined width. Therefore, direct abutment between the end face of the fusing belt **110** and each of the restricting surfaces **311**A and **321**A can be prevented even if the fusing belt **110** displaces (moves) in the radial direction thereof during its circular movement. As a result, occurrence of a crack on the end faces of the fusing belt **110** can be suppressed, thereby serving to prolonged service life of the fusing belt **110**.

Further, the lubricant G is applied onto the arcuate-shaped specific area on the restricting surfaces **311**A and **321**A within which the end faces of the fusing belt **110** are possibly abuttable against the restricting surfaces **311**A and **321**A. This ensures that the lubricant G is provided between each end face of the fusing belt **110** and its corresponding restricting surface **311**A or **321**A, thereby more reliably preventing direct abutment therebetween. Further prolonged service life of the fusing belt **110** can be therefore achieved.

The fusing belt **110** of the present embodiment has the metal base tube **111** and therefore has a durability higher than that of a resin fixing belt to achieve longer service life. On the other hand, since the both end faces of the base tube **111** are exposed (not covered with the coating layer **112**), conceivably, not only the end faces of the base tube **111** but also the restricting surfaces **311**A and **321**A could become worn out and be damaged if the end faces directly abut against the restricting surfaces **311**A and **321**A. However, in the fixing device **100** of the present embodiment, continuous application of the lubricant G on the restricting surfaces **311**A and **321**A along the circumferential direction of the fusing belt **110** prevents direct abutment of the end faces of the fusing belt **110** with the restricting surfaces **311**A and **321**A. Thus, the configuration of the present embodiment is particularly effective in a configuration in which the fusing belt **110** has the metal base tube **111**.

Further, in the present embodiment, the coating layer **112** made of a fluorine resin is formed on the outer peripheral surface of the base tube **111**. Therefore, compared to a case where the coating layer **112** is not provided on the outer peripheral surface of the base tube **111**, a contact area between each end face of the fusing belt **110** and each of the restricting surfaces **311**A and **321**A can be increased by the thickness of the coating layer **112**. This configuration can achieve a decrease in pressure at the contact area, thereby suppressing load from being applied to the end faces of the fusing belt **110**. Longer service life can be thus achieved.

Further, as illustrated in FIG. **7**, the inner guides **240** are formed adjacent to and inward of the end-face restricting member **300** in the left-right direction. Therefore, as the fusing belt **110** is circularly moved, the lubricant G, which has been retained between the end faces of the fusing belt **110** and the restricting surfaces **311**A, **321**A (only one of which is shown), enters into the internal space of the fusing belt **110** and is supplied between the inner peripheral surface of the fusing belt **110** and the guide surfaces **240**A of the respective inner guides **240**. This can suppress abrasion of the inner peripheral surface of the fusing belt **110**, thereby contributing to further prolongation of the service life of the fusing belt **110**.

Further, in the present embodiment, the inner guides **240** and end-face restricting members **300** are provided as separate members (separate parts). Therefore, no protruding portions functioning as the inner guides **240** are necessary to be formed on the restricting surfaces **311**A and **321**A. In other words, the restricting surfaces **311**A and **321**A are easy to be formed as being flat surfaces having no irregularity, thereby allowing the lubricant G to be easily applied onto the specific areas on the restricting surfaces **311**A and **321**A.

<Production Method of Fixing Device>

Next, a production method of the fixing device **100** will be described. More specifically, of a series of processes to produce the fixing device **100**, how to apply the lubricant G onto the restricting surfaces **311**A, **321**A of the end-face restricting members **300** (lubricant application process) will be described with reference to FIGS. **9**A through **9**C.

The lubricant application process is performed before the end faces of the fusing belt **110** and the restricting surfaces **311**A and **321**A of the end-face restricting member **300** are placed to face each other, specifically, before the end-face restricting members **300** are assembled to the frame assembly **200**.

Firstly, as illustrated in FIG. **9**A, the right end-face regulating member **310** and left end-face regulating member **320** are set onto a jig **500** such that the restricting surfaces **311**A and **321**A face upward and the engaged portions **312** and **322** oppose each other. Then, the jig **500**, in which the end-face restricting members **300** (right end-face regulating member **310** and left end-face regulating member **320**) have been in place, is set in a lubricant application device (not shown).

Then, as illustrated in FIG. **9**B, a predetermined amount of lubricant G is supplied from a dispenser **610** of the lubricant application device (not shown) while the jig **500** is rotated in a clockwise direction in FIG. **9**B. The lubricant G is thus continuously applied onto the restricting surfaces **311**A and **321**A so as to follow the circumferential direction of the fusing belt **110**. Concurrently, the lubricant G is flattened into an arcuate shape having a predetermined width by the rotation of the jig **500** as well as by a paddle **620** disposed adjacent to and downstream of the dispenser **610** in the rotational direction of the jig **500**.

In the lubricant application process of the present embodiment, the jig **500** is rotated twice. During a first rotation, as described above, the lubricant G supplied from the dispenser **610** is continuously applied in the rotation direction, while being flattened by the paddle **620**. During a second rotation, as illustrated in FIG. **9**C, the lubricant G is no longer supplied from the dispenser **610**, and only the paddle **620** performs flattening of the lubricant G.

After rotation of the jig **500** is stopped, the jig **500** is removed from the lubricant application device, and the end-face restricting members **300** are then removed from the jig **500**.

As a result, the lubricant G is applied onto the restricting surfaces **311**A and **321**A of the end-face restricting members **300** in a continuous manner to form the arcuate-shaped specific areas on the restricting surfaces **311**A, **321**A (see also FIGS. **6**A and **6**B). Preferably, as described earlier, when the end-face restricting members **300** are removed from the jig **500**, the restricting surfaces **311**A and **321**A have the lubricant G applied thereon in the arcuate-shaped specific area as a whole within which the end faces of the fusing belt **110** possibly abut against the restricting surfaces **311**A and **321**A.

After the lubricant application process is completed, the end-face restricting members **300** are assembled to the frame assembly **200** in an assembly process. The restricting surfaces **311**A and **321**A are arranged so as to face respective end faces of the fusing belt **110** in the axial direction. It should be noted that, in the assembly process, as illustrated in FIG. **8**, one of the end-face restricting members **300** (either one of the right end-face regulating member **310** and left end-face regulating member **320**) is first assembled to the frame assembly **200**, and then the fusing belt **110** is mounted on the frame assembly **200** from a side opposite to the side at which one of the end-face restricting members **300** has been assembled. Subsequently, remaining one of the end-face restricting members **300** is assembled to the frame assembly **200**. The restricting surfaces **311**A and **321**A are thus arranged to face the end faces of the fusing belt **110**.

Further, the inner guide **240** provided on the frame assembly **200** has the slopes **240**B on both left and right sides of the guide surface **240**A, so that the end face of the fusing belt **110** can be guided by the slopes **240**B while the fusing belt **110** is being mounted (inserted) so as to cover the frame assembly **200**. Thus, the end face of the fusing belt **110** can be prevented from getting stuck with the inner guide **240**, thereby realizing smooth mounting of the fusing belt **110** onto the frame assembly **200**. Damages to the fusing belt **110** at the time of assembly can therefore be restrained, thereby serving to prolongation of the service life of the fusing belt **110**.

In the fixing device **100** thus produced, the lubricant G is continuously applied between each end face of the fusing belt **110** and corresponding one of the restricting surfaces **311**A and **321**A along the circumferential direction of the fusing belt **110**. Therefore, the end faces of the fusing belt **110** can be prevented from being in direct contact with the restricting surfaces **311**A and **321**A from the beginning of the use of the fixing device **100**. Further, in the lubricant application process, the applied lubricant G is flattened into an arcuate shape having a predetermined width. Hence, direct abutment between each end face of the fusing belt **110** and each restricting surface **311**A or **321**A can be prevented even if the circular movement of the fusing belt **110** causes the fusing belt **110** itself to move (displace) in the radial direction. As a result, occurrence of a crack on the end faces of the fusing belt **110** can be suppressed, thereby prolonging the service life of the fusing belt **110**.

Various modifications are conceivable.

In the depicted embodiment, the inner guide **240** has the sloped surfaces **240**B on both sides of the guide surface **240**A in the axial direction, but the sloped surface **240**B may be formed only inward of the guide surface **240**A in the axial direction. Conceivably, when being fitted over the frame assembly **200**, the fusing belt **110** (tubular member) can relatively easily go over the inner guide **240** provided at a near side (upstream) in a mounting direction of the fusing belt **110**, since an angle of the fusing belt **110** at which the fusing belt **110** is inserted can be changed appropriately by tilting the fusing belt **110** at this time. However, as the fusing belt **110** is inserted deeper toward a far side (downstream) in the mount-

ing direction, changing the angle of the fusing belt **110** becomes harder, thus increasing a possibility that the end face of the fusing belt **110** gets stuck with the inner guide **240** formed on the far side in the mounting direction. Nonetheless, the formation of the sloped surface **240**B inward of the guide surface **240**A in the axial direction can prevent the fusing belt **110** from being stuck with, especially, the inner guide **240** on the far side.

Further, although the inner guides **240** of the embodiment are formed adjacent to and inward of the respective end-face restricting members **300** in the axial direction, the inner guides **240** may be disposed away from the end-face regulating members **300**. Still alternatively, more than three inner guides **240** may be provided at both end portions of the frame assembly **200** and a portion interposed therebetween.

As a further alternative to the inner guide **240** of the embodiment, FIG. **10** shows an inner guide **260** according to a first modification of the present invention. Instead of the inner guide **240** configured of the first guide **241** formed on the first frame **210** and the second guide **242** formed on the second frame **220**, the inner guide **260** of the first modification is formed only on the second frame **220** that covers the first frame **210**. Specifically, the inner guide **260** has a guide surface (shown without a reference numeral) that protrudes from the second frame member **220** to have a generally semi-circular arcuate shape in a side view. With this construction, the guide surface of the inner guide **260** can be formed in a seamless manner, so that the inner peripheral surface of the moving fusing belt **110** can be guided reliably.

With regard to the frame assembly **200**, the frame assembly **200** of the embodiment is configured of two separate members (first frame member **210** and second frame member **220**). However, the frame assembly **200** may be configured of a single member, or more than three separate members.

Further, the end faces of the base tube **111** of the fusing belt **110** (tubular member) are exposed in the embodiment, but the end faces of the base tube **111** may each be covered with a coating layer. Further, instead of a metal, the base tube **111** may be formed of a resin such as polyimide resin or a material having elasticity such as a rubber. Further, instead of the fusing belt **110** of the embodiment having a multi-layer structure configured of the base tube **111** and the coating layer **112**, the fusing belt **110** may have a single-layer structure consisting solely of the base tube **111**. Still alternatively, the inner peripheral surface of the base tube **111** may be covered with a coating layer.

In the above embodiment, the nip plate **130** and backup roller **140** are exemplified as the first fixing member and second fixing member, respectively. However, the first fixing member may be, for example, a member that is configured to guide the inner peripheral surface and support a ceramic heater as the heat source. The second fixing member may be a belt-like shaped backup member or a plate-like shaped backup member that does not rotate.

Further, the end-face restricting members **300** of the embodiment may also have other configurations. For example, a flange-like shaped member may serve as the end-face restricting members **300**.

FIG. **11** shows a right end-face restricting member **330** and a left end-face restricting member **340** according to a second modification of the present invention. The right end-face restricting member **330** and the left end-face restricting member **340** are formed in a generally U-shape in a plan view, respectively. The right end-face restricting member **330** and the left end-face restricting member **340** have restricting surfaces **331**A, **341**A and engaged portions **332**, **342** respectively. In the lubricant application process, when set in the jig **500**, both the right end-face restricting member **330** and the left end-face restricting member **340** are placed such that the restricting surfaces **331**A and **341**A face upward and the engaged portions **332** and **342** oppose each other. At this time, the right end-face restricting member **330** and the left end-face restricting member **340** are positioned so as not to provide a large gap therebetween, the gap being formed by end faces **331**B of the right end-face restricting member **330** and end faces **341**B of the left end-face restricting member **340**, as shown in FIG. **11**. With this arrangement, the lubricant G can be efficiently applied to the restricting surfaces **331**A and **341**A.

In the production method (lubricant application process) of the fixing device **100** of the above embodiment, the paddle **620** functions to flatten the applied lubricant G, while the dispenser **610** applies the lubricant G onto the restricting surfaces **311**A and **321**A. However, other lubricant application methods are also available. For example, the application of the lubricant G and the flattening of the lubricant G may be performed separately, before the fusing belt **110** is assembled to the frame assembly **200**. Specifically, firstly, the lubricant G may be continuously applied onto the restricting surfaces **311**A and **321**A along the circumferential direction of the fusing belt **110**; and thereafter the applied lubricant G is flattened into an arcuate shape in a separate process. Still alternatively, before the end faces of the fusing belt **110** and the restricting surfaces **311**A and **321**A are arranged so as to face each other, the lubricant G may be applied onto the restricting surfaces **311**A and **321**A in a dot-like pattern, and thereafter the lubricant G applied onto the restricting surfaces **311**A and **321**A may be spread into an arcuate shape with a predetermined width in a separate process.

Further, the sheet S can be an OHP sheet instead of a plain paper and a postcard.

Further, in the depicted embodiment, the present invention is applied to the monochromatic laser printer **1** as an example of an image forming apparatus incorporating the fixing device **100** of the embodiment. However, a color laser printer, a copying machine and a multifunction device provided with a scanning device, such as a flat-head scanner are also available.

While the invention has been described in detail with reference to the embodiments thereof, it would be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention.

What is claimed is:

1. A fixing device comprising:

a flexible tubular member having an inner peripheral surface defining an internal space and an outer peripheral surface opposite to the inner peripheral surface, the flexible tubular member defining an axis extending in an axial direction and having end faces in the axial direction;

a first fixing member disposed in the internal space;

a second fixing member configured to nip the flexible tubular member in cooperation with the first fixing member;

a pair of restricting members disposed to interpose the flexible tubular member therebetween in the axial direction, each restricting member having a restricting surface abuttable with each end face of the flexible tubular member to restrict the flexible tubular member from moving in the axial direction;

a pair of inner guides each disposed inward of each of the pair of restricting members in the axial direction and configured to guide the inner peripheral surface of the

flexible tubular member, each restricting member being a separate member from each inner guide; and

a lubricant provided between each restricting surface and each end face of the flexible tubular member and between each inner guide and the inner peripheral surface of the flexible tubular member, the lubricant being also provided on each restricting surface at a position outward relative to the outer peripheral surface of the flexible tubular member in a radial direction perpendicular to the axial direction and being continuous with the lubricant provided between each restricting surface and each end face of the flexible tubular member, the lubricant being also provided between each restricting surface and a portion of each inner guide in the axial direction.

2. The fixing device as claimed in claim **1**, wherein:

the flexible tubular member has a circumference defining a circumferential direction and has a thickness in the radial direction; and

each restricting surface has a specific area continuously applied with the lubricant upon completion of assembly of the fixing device, the specific area having an arcuate shape extending in the circumferential direction and having a width in the radial direction, the arcuate shape having a central angle smaller than 180 degrees.

3. The fixing device as claimed in claim **2**, wherein the width of the specific area is defined as a range within which each end face of the flexible tubular member is possibly abuttable with each restricting surface while the flexible tubular member circularly moves.

4. The fixing device as claimed in claim **2**, wherein the width of the specific area is in a range of 4.0 to 4.5 mm.

5. The fixing device as claimed in claim **1**, wherein the flexible tubular member comprises a base tube made of a metal.

6. The fixing device as claimed in claim **5**,

wherein the base tube has an outer peripheral surface; and

wherein the flexible tubular member further comprises a coating layer provided on the outer peripheral surface of the base tube.

7. The fixing device as claimed in claim **6**, wherein the base tube has base end faces in the axial direction that are not covered with the coating layer.

8. The fixing device as claimed in claim **1**, wherein the restricting surfaces are formed as a flat surface without irregularity.

9. The fixing device as claimed in claim **1**, wherein each inner guide is disposed adjacent to each restricting member in the axial direction.

10. The fixing device as claimed in claim **1**, wherein each inner guide comprises:

a guide surface configured to guide the inner peripheral surface of the flexible tubular member; and

a sloped surface positioned outward of the guide surface in the axial direction, the sloped surface sloping away from the inner peripheral surface toward the restricting surface, the lubricant being provided between each restricting surface and each sloped surface.

11. The fixing device as claimed in claim **10**, wherein each inner guide is disposed adjacent to and inward of each restricting surface in the axial direction, and

wherein each restricting surface and each sloped surface define a V-shaped cross-section to retain the lubricant.

12. The fixing device as claimed in claim **1**, wherein the first fixing member and the second fixing member are configured to nip the flexible tubular member therebetween to form a nip region where a sheet is conveyed in a sheet conveying direction, and

wherein each restricting surface comprises an upstream portion and a downstream portion positioned opposite to each other with respect to the nip region in the sheet conveying direction, wherein a surface area of the upstream portion is different than a surface area of the downstream portion.

13. The fixing device as claimed in claim **12**, wherein the surface area of the downstream portion is larger than the surface area of the upstream portion.

14. The fixing device as claimed in claim **1**, wherein each restricting member further comprises an opposite surface opposite to the restricting surface in the axial direction and an end face connecting the restricting surface and the opposite surface, the lubricant being further provided on the end face.

15. The fixing device as claimed in claim **1**, wherein each inner guide comprises:

a guide surface configured to guide the inner peripheral surface of the flexible tubular member, the lubricant being provided between each restricting surface and each guide surface;

a first sloped surface positioned outward of the guide surface in the axial direction, the first sloped surface sloping away from the inner peripheral surface toward each restricting surface, the lubricant being provided between each restricting surface and each first sloped surface; and

a second sloped surface positioned inward of the guide surface in the axial direction, the second sloped surface sloping away from the inner peripheral surface toward the axis of the flexible tubular member.

* * * * *